

Crash Test Dummies: How they are developed to help save lives in vehicle crashes



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March 27, 2013

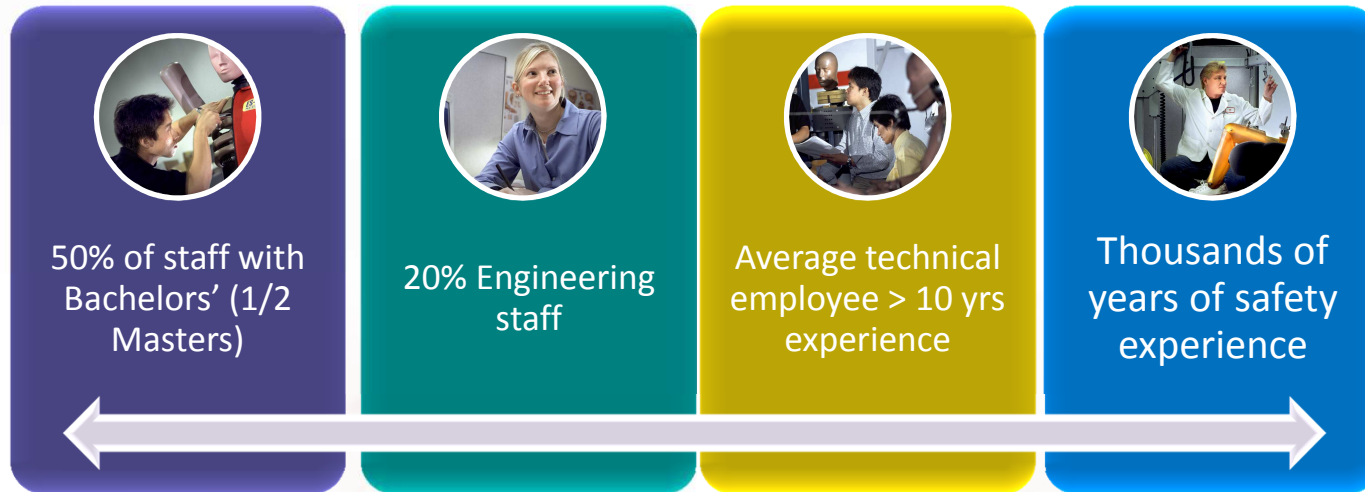
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Our People (approximately 400 worldwide)



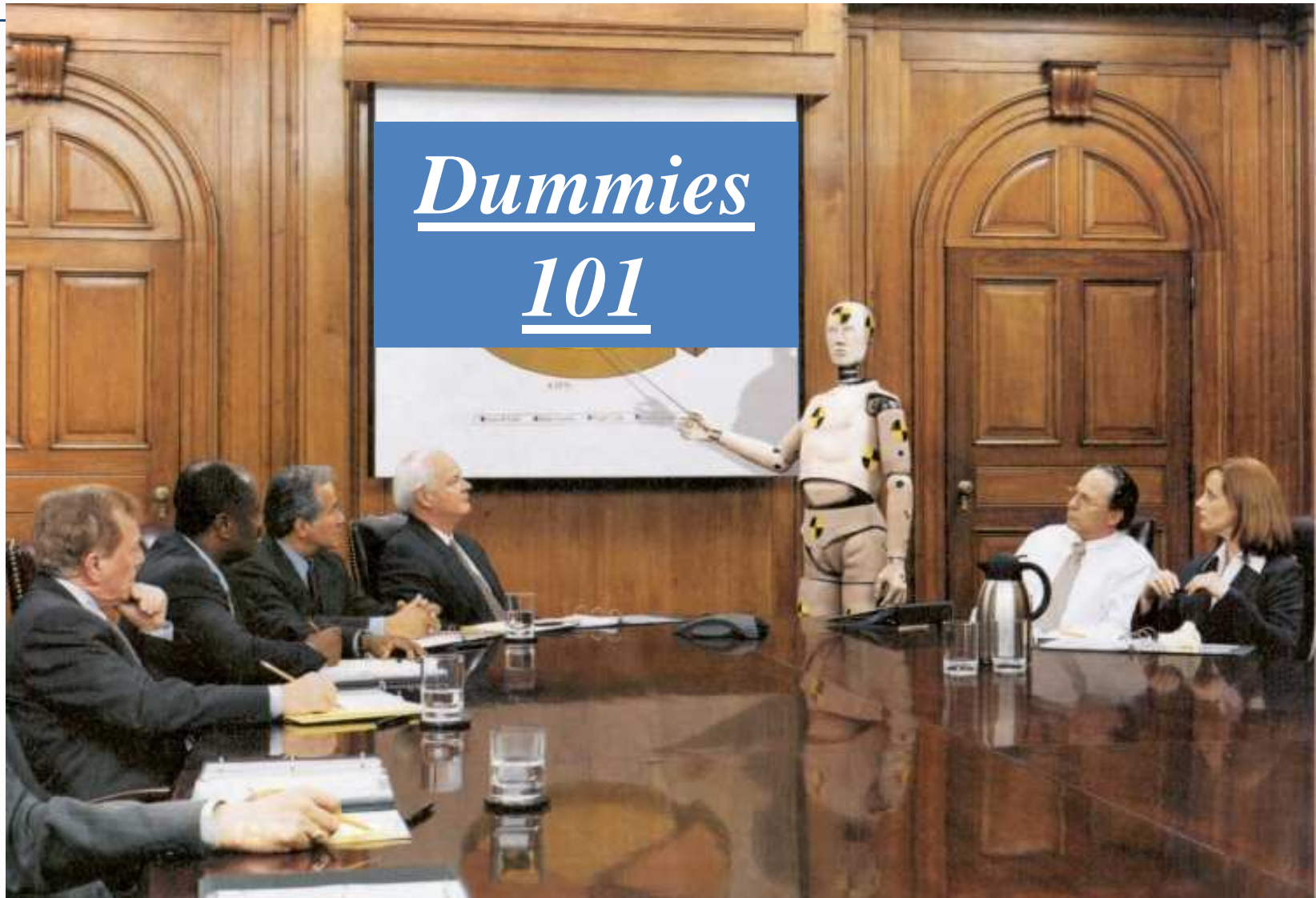
Agenda

Anthropomorphic Test Devices (crash dummies) have been designed throughout the years to address different population sizes and weights

Over the years many sizes have been needed to test ejection seats, automotive restraint systems, flotation devices, passenger aircraft seats, child seats, children's playground equipment, sports equipment, etc.... The design of these have used many of the same basic type of design and materials.



Anthropomorphic Test Devices (ATD)



Dummies at Work



Dummy Jump from Space



Ejection Seat Testing



Riding the Train



Taking a Bus Trip



Plane Crash Testing



Helicopter Rides



Military Blast Testing



Live Fire Manikins

- Hybrid III

- Additions

- Focus Head
 - Mil Mx Lower Legs
 - Load cells
 - Pressure sensors



- LiveMan

- Blunt Trauma
 - Vertical compliance
 - Fragment detection Thorax
 - Load cells
 - Pressure Sensors

- AirMan

- Fragment detection complete body

- Mil SID

- Side Impact Dummy w/Mil MX legs



Rescue Training Dummies



Auto Crash Testing



Motorcycle and Bike Riders

Roller Coaster Rider

- School Bus Safety
- Motorcycle Safety
- Bicycle Safety
- Roller Coaster



Pedestrian Testing



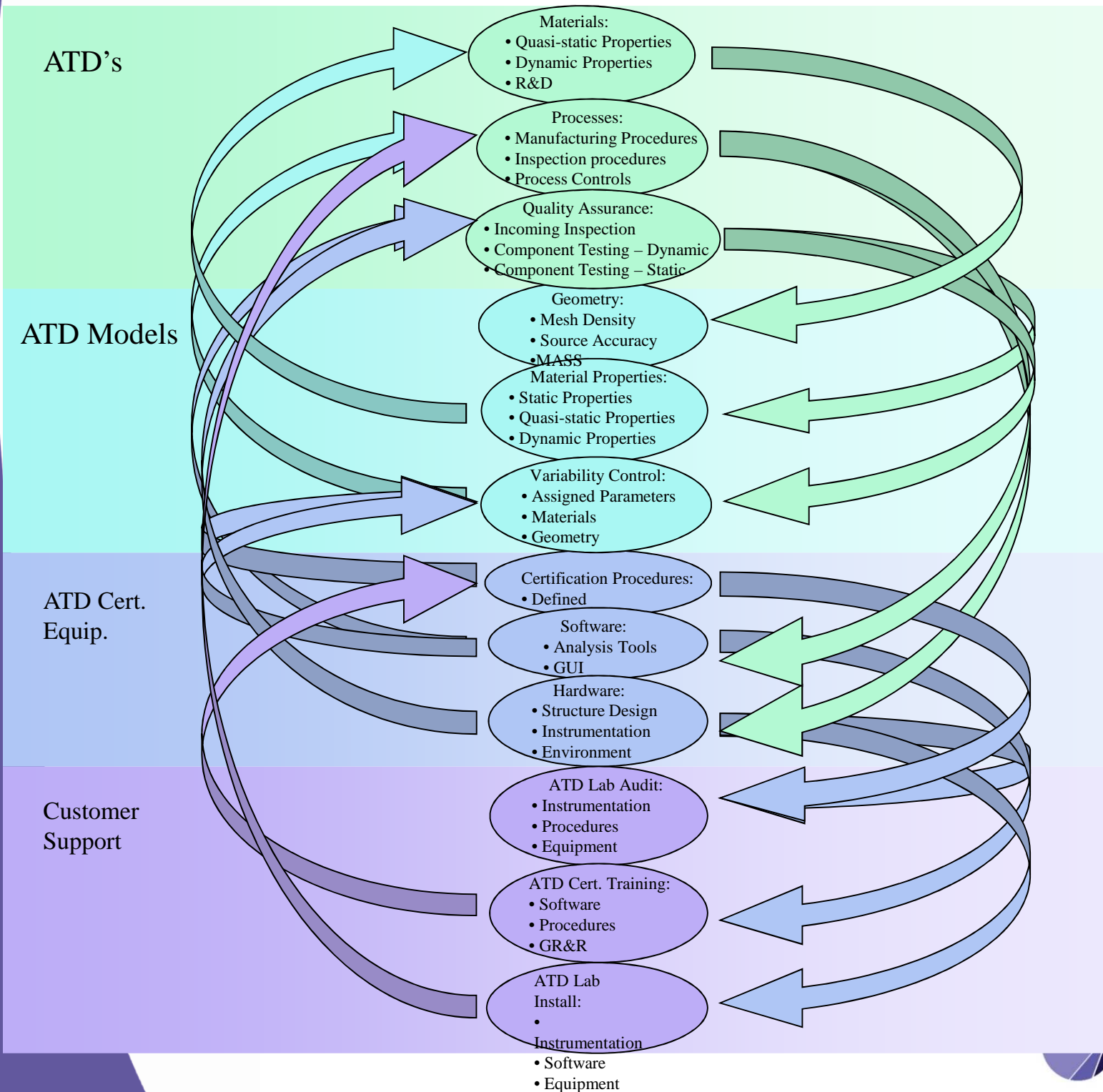
Dummies going for a Swim or ride in a Tractor



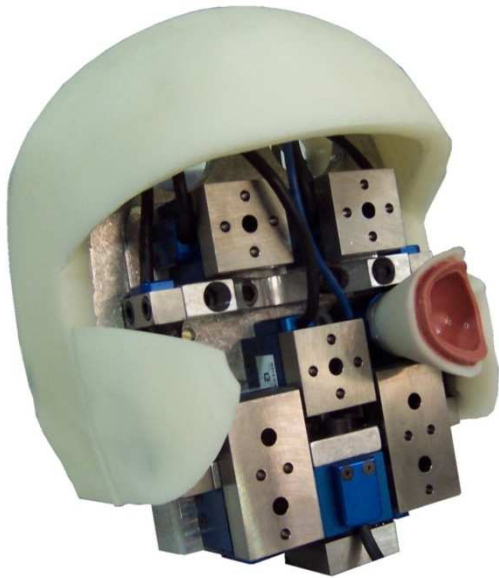
What makes a good ATD?

- Weight
- Stature
- Reproducible
- Repeatable
- Costs
- Ability to measure with many transducers
- Biofidelity

ATD Development Model



Measuring for Eye and Face Injuries



Load cell support structure = aluminum

Eye & Zygoma load cells = steel

All other load cells = titanium



Skull - urethane

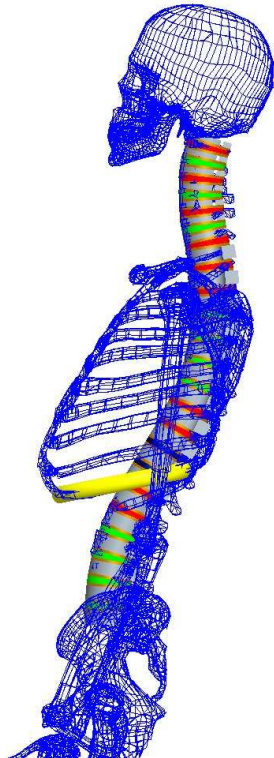
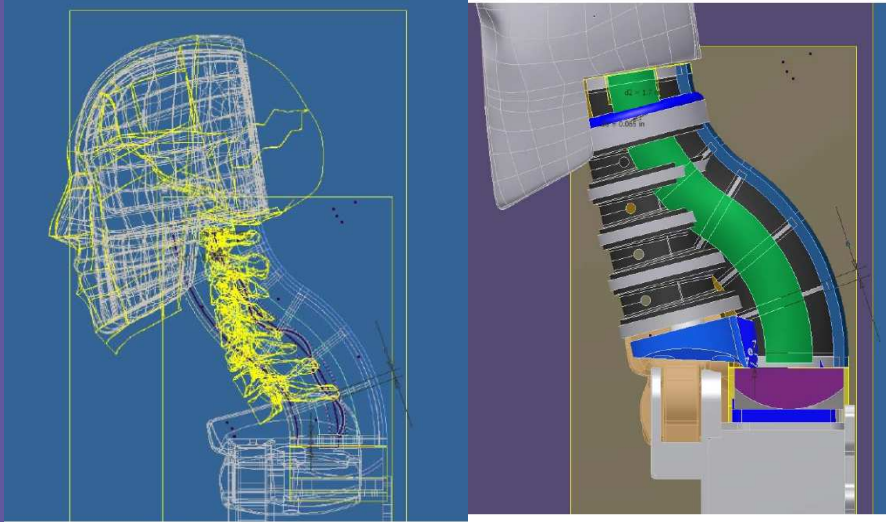


Skin - urethane

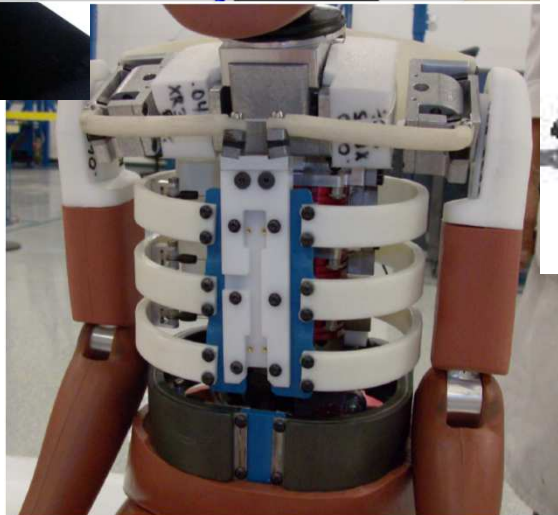
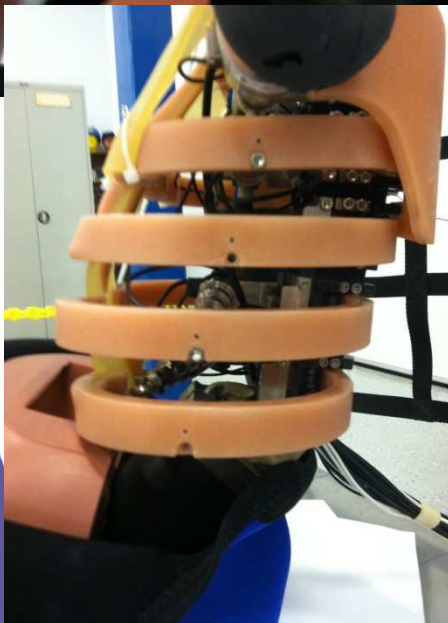
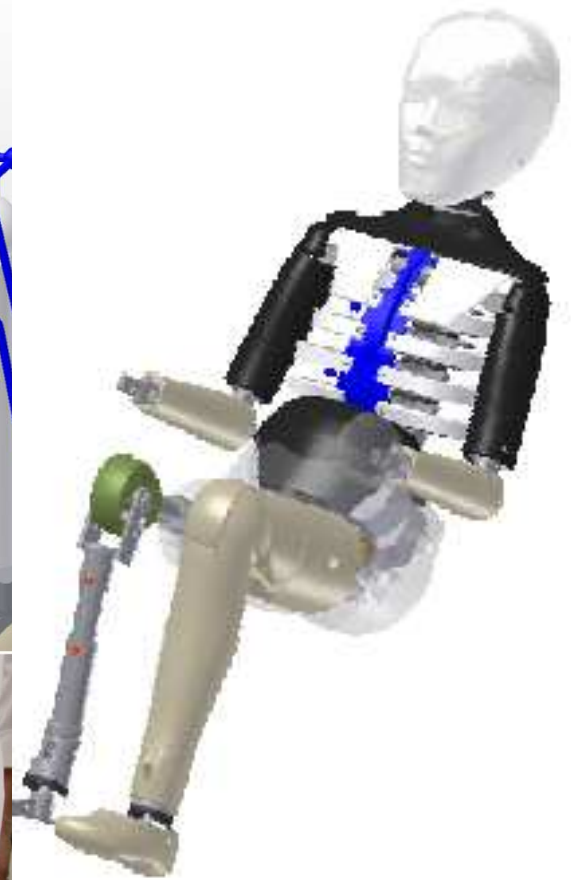
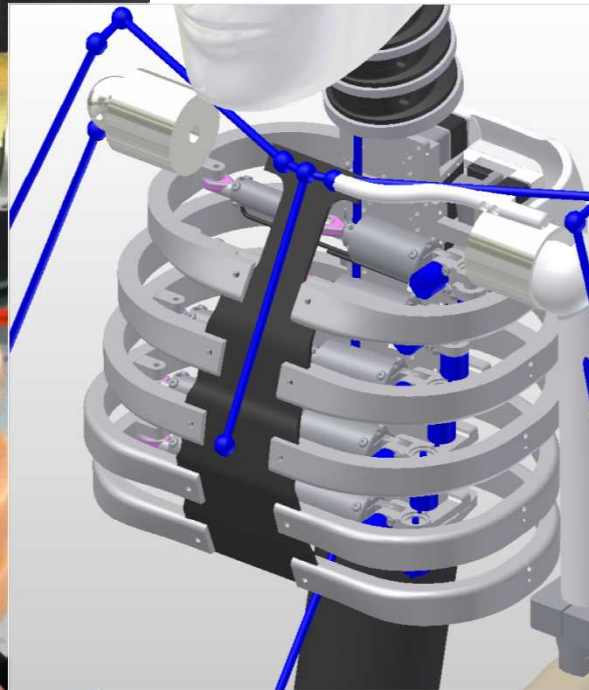
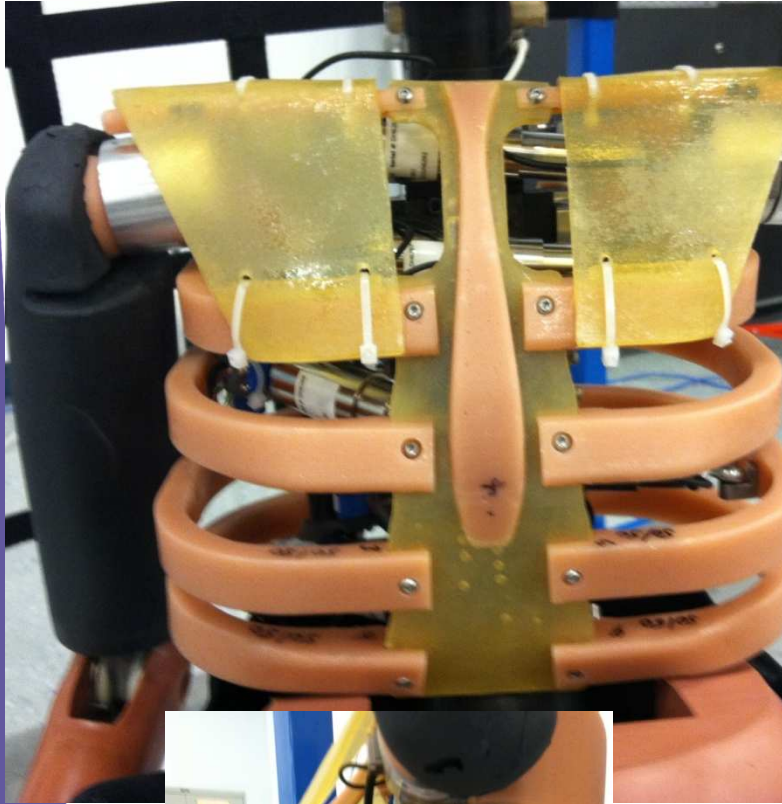
Brain Injury?



Measuring for neck and Spine injuries



Measuring for Shoulder and Thorax Injuries



Measuring for Leg, Tibia, and Foot Injuries



Three Types of ATD's to Represent a Human



1. Overall size and weight



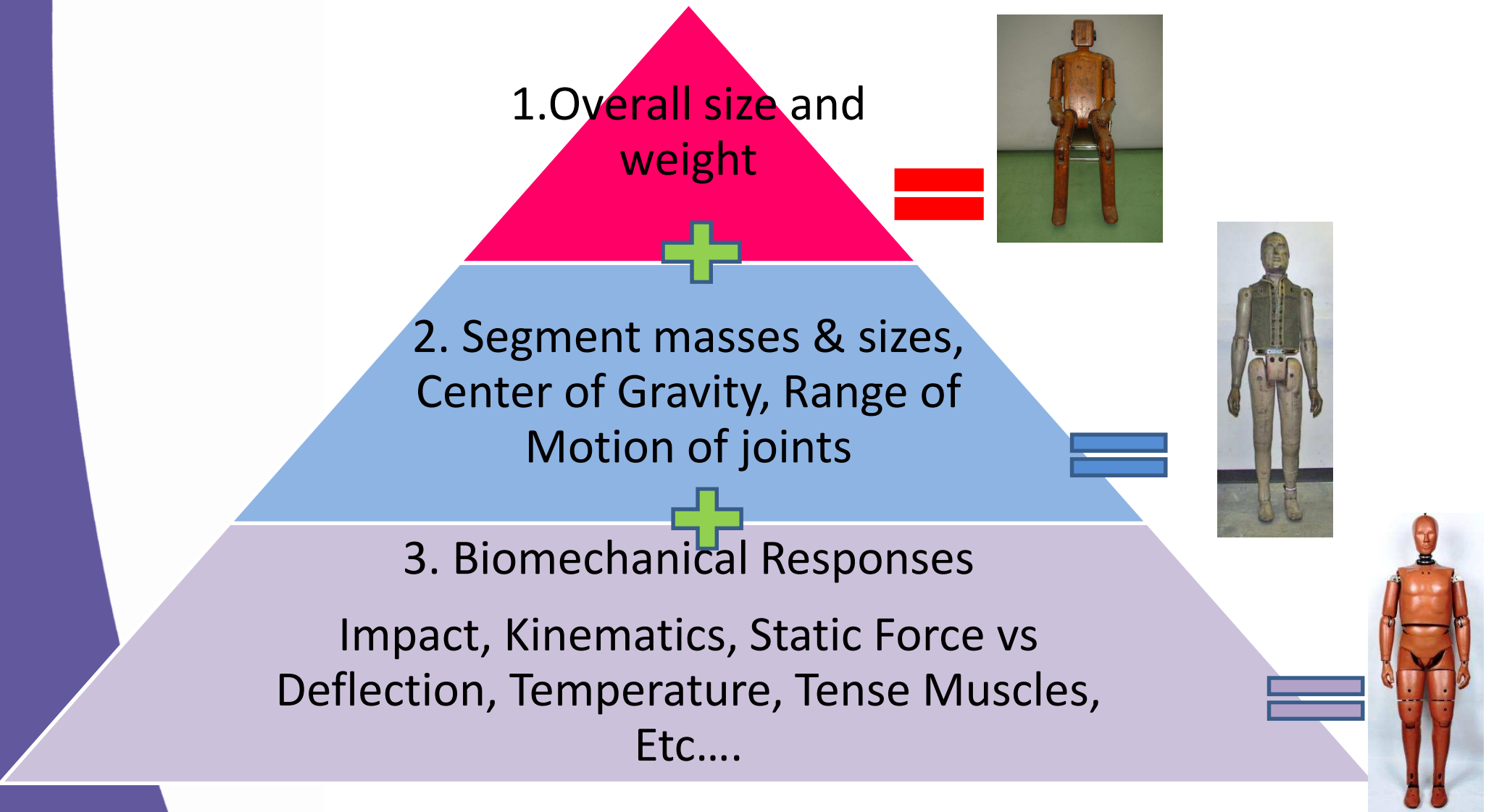
2. Segment masses & sizes,
Center of Gravity, Range of
Motion of joints



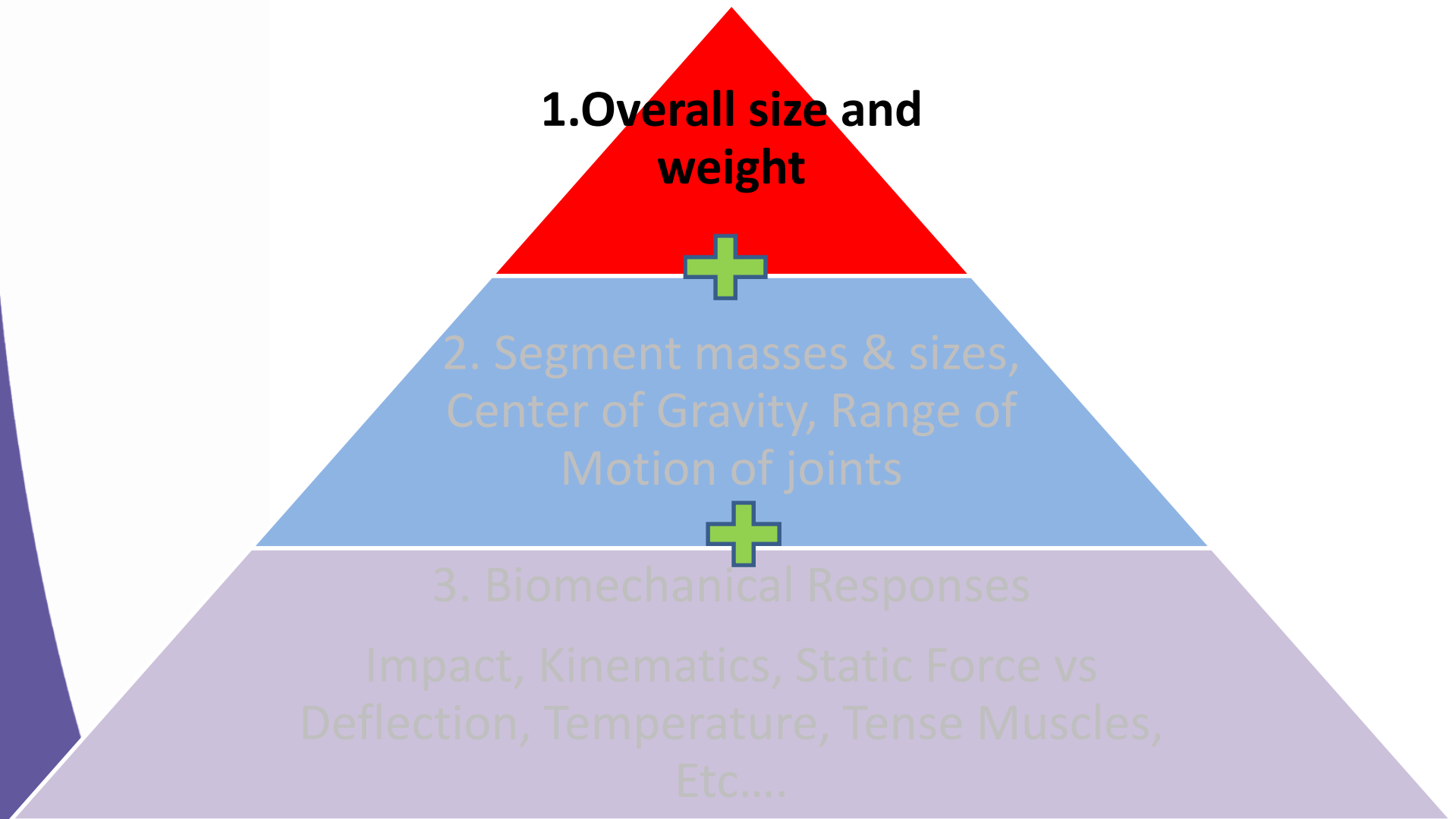
3. Biomechanical Responses

Impact, Kinematics, Static Force vs
Deflection, Temperature, Tense Muscles,
Etc....

Three Types of ATD's to Represent a Human



First Type of ATD's to Represent a Human



TYPE 1 ATD's

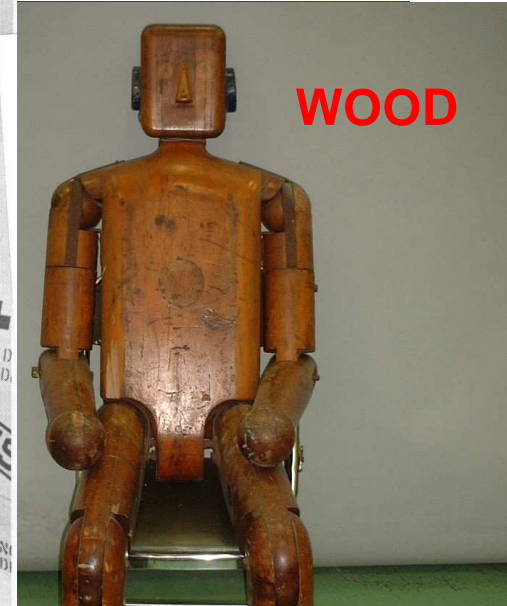


Bean Bags



Pierre the dummy gives the Aircraft Rescue Crew a chance to polish up their quick rescue techniques

OFFICIAL U.S. NAVY PHOTO



WOOD



Foam with leather skeleton

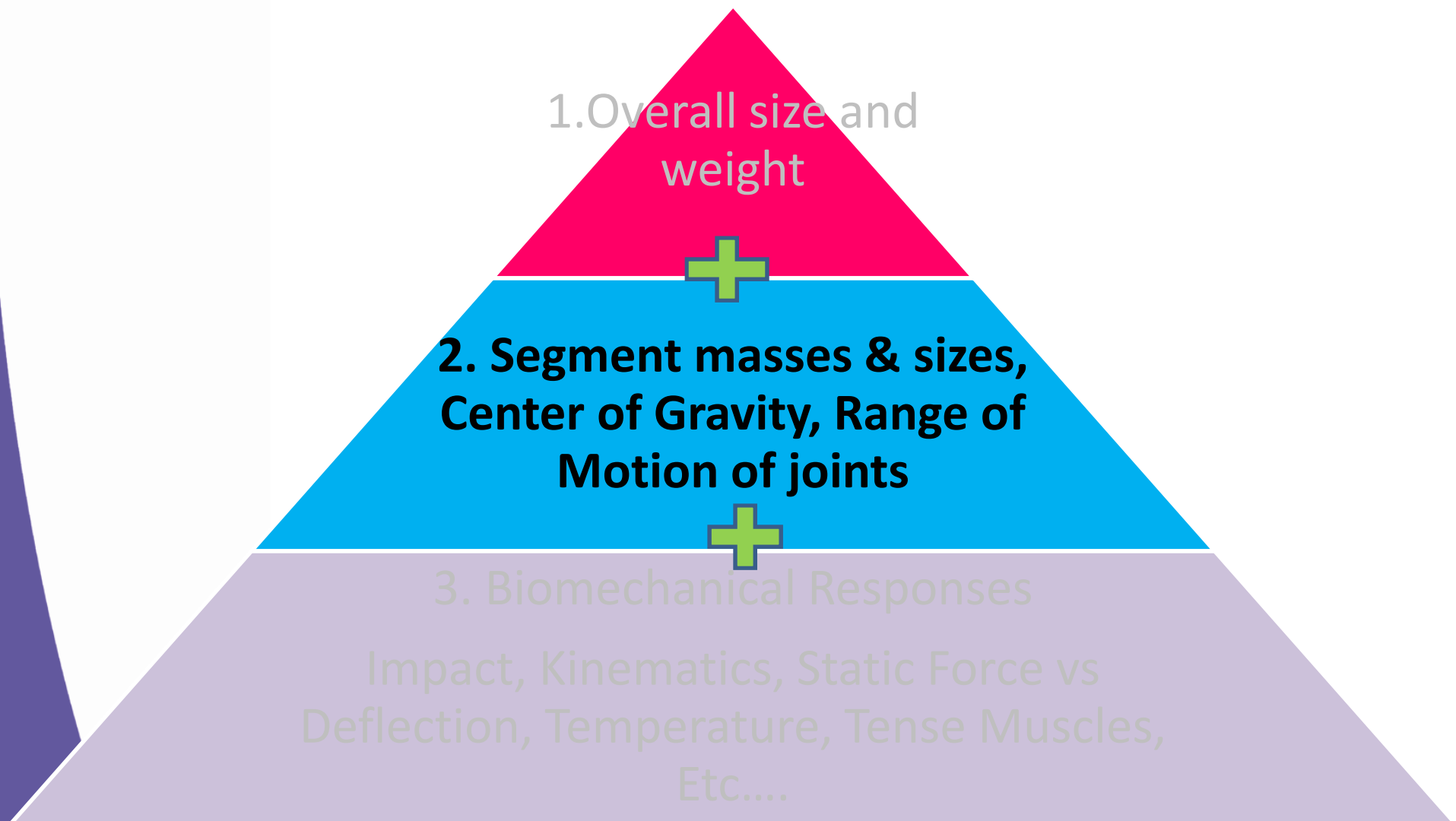


ROPE Dummies

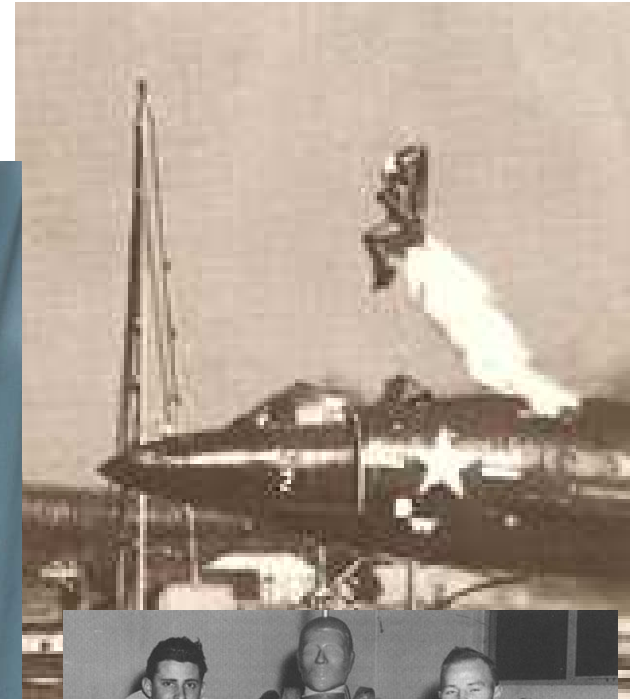
TYPE 1 ATD's



Second Type of ATD's to Represent a Human

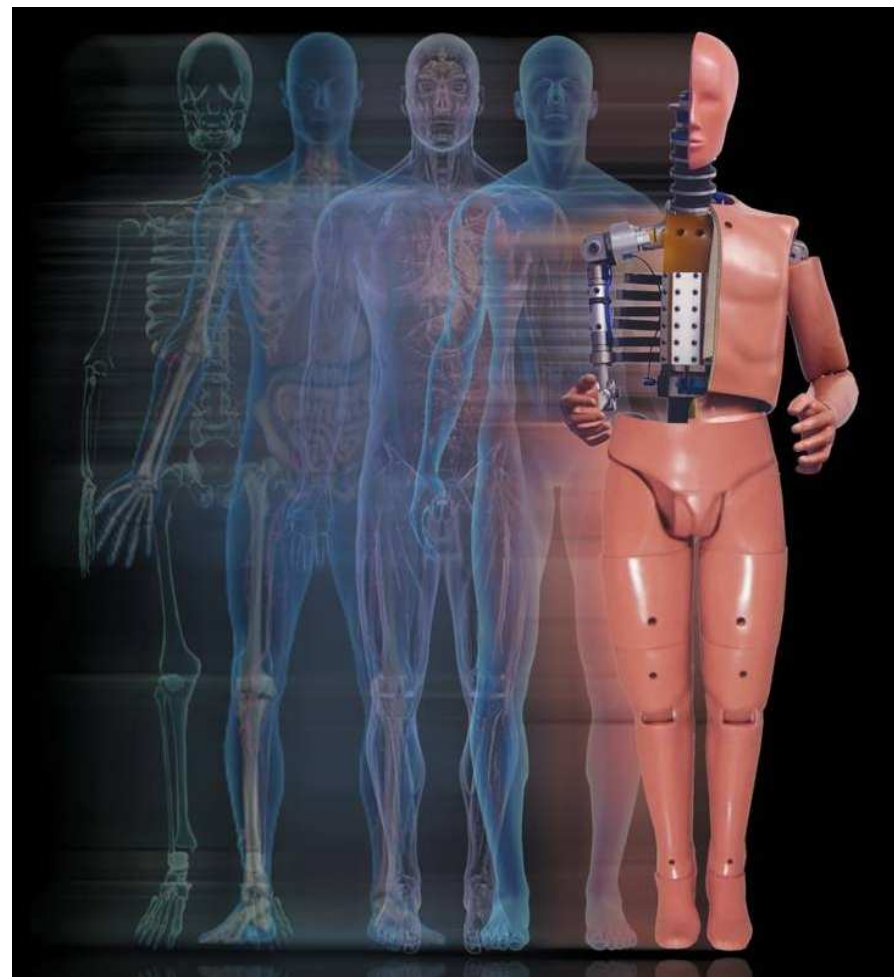


TYPE 2 ATD's

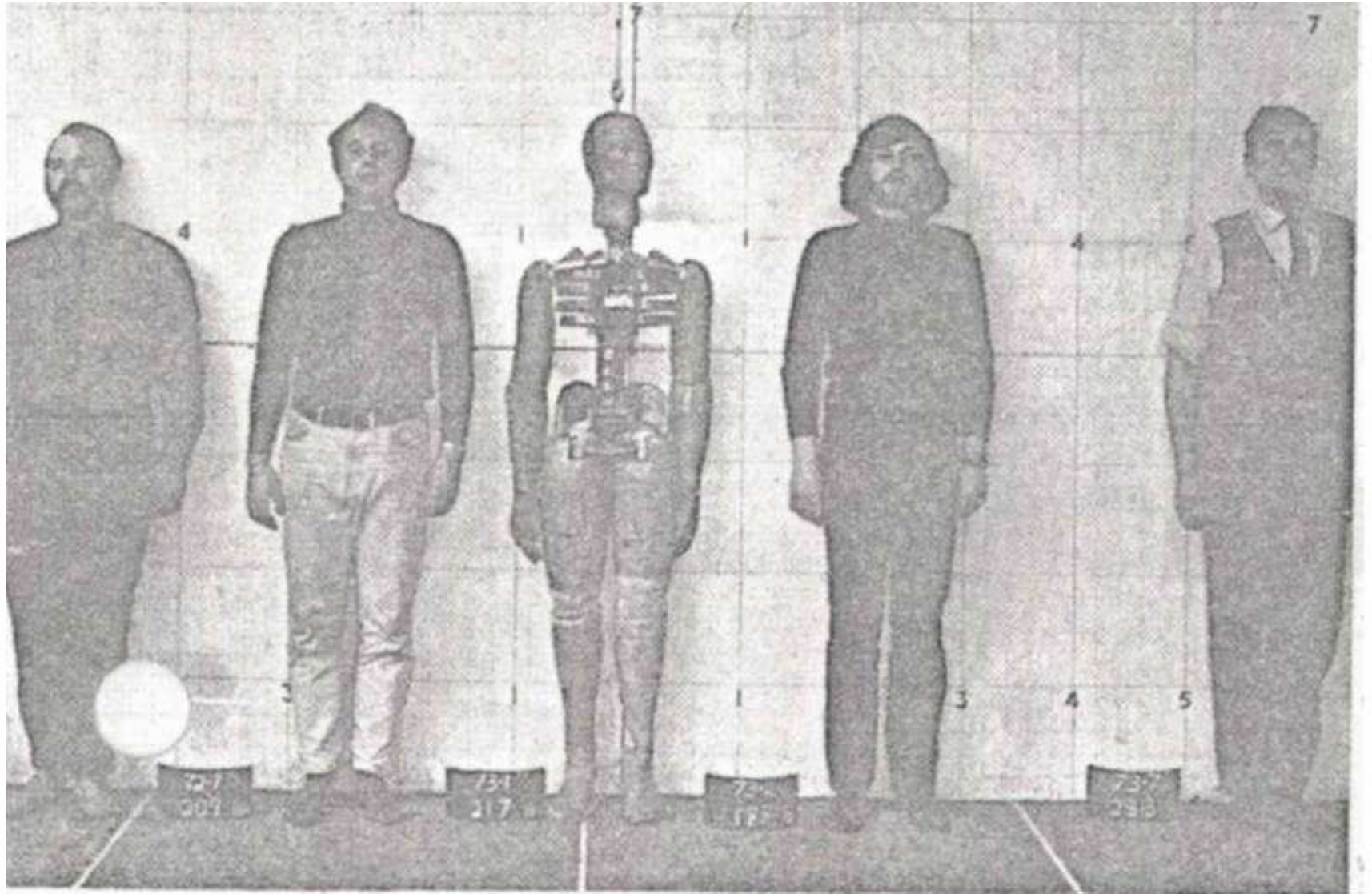


What do we need to know to develop TYPE 2 ATD's?

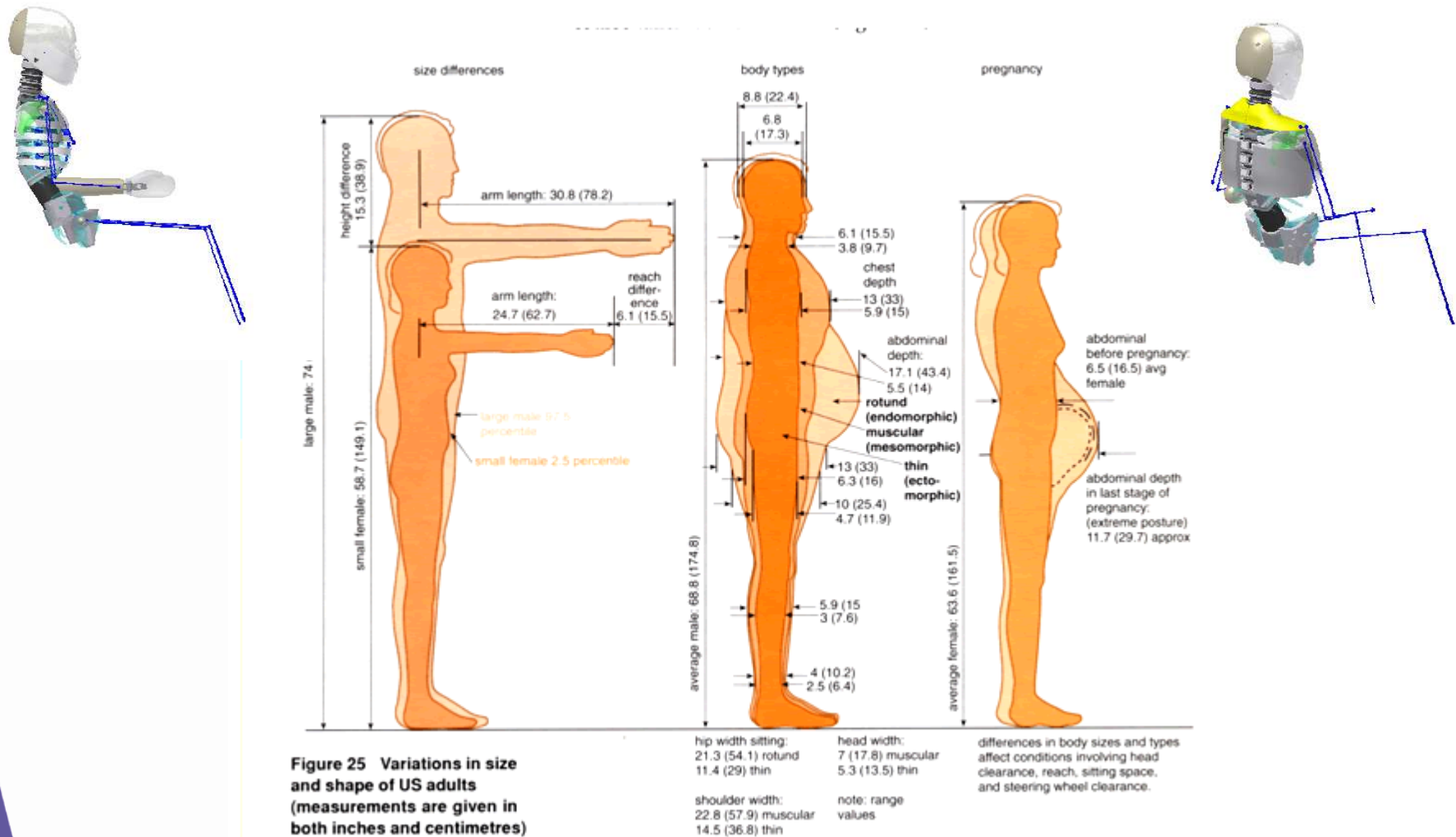
- Detailed Anthropometry
 - Segment mass
 - Segment CG
 - Segment shape
 - Segment lengths
 - Joint Center locations
 - Relationship between skeleton and outside shape
 - ROM of joints
 - Measurements from different percentiles



Anthropometry



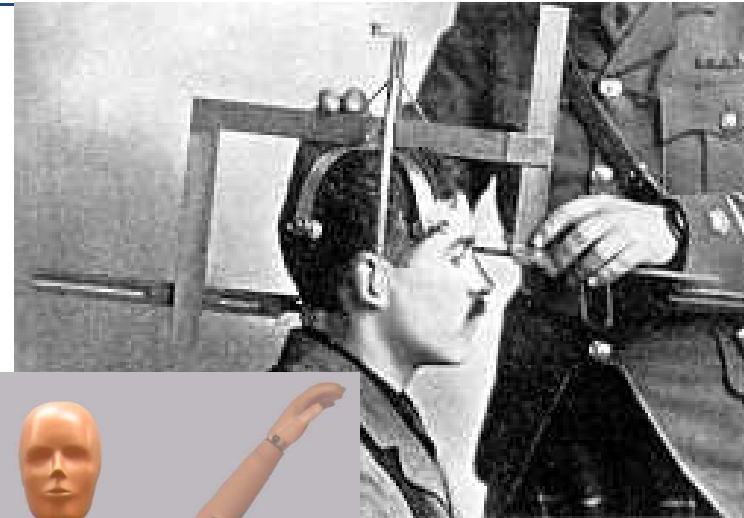
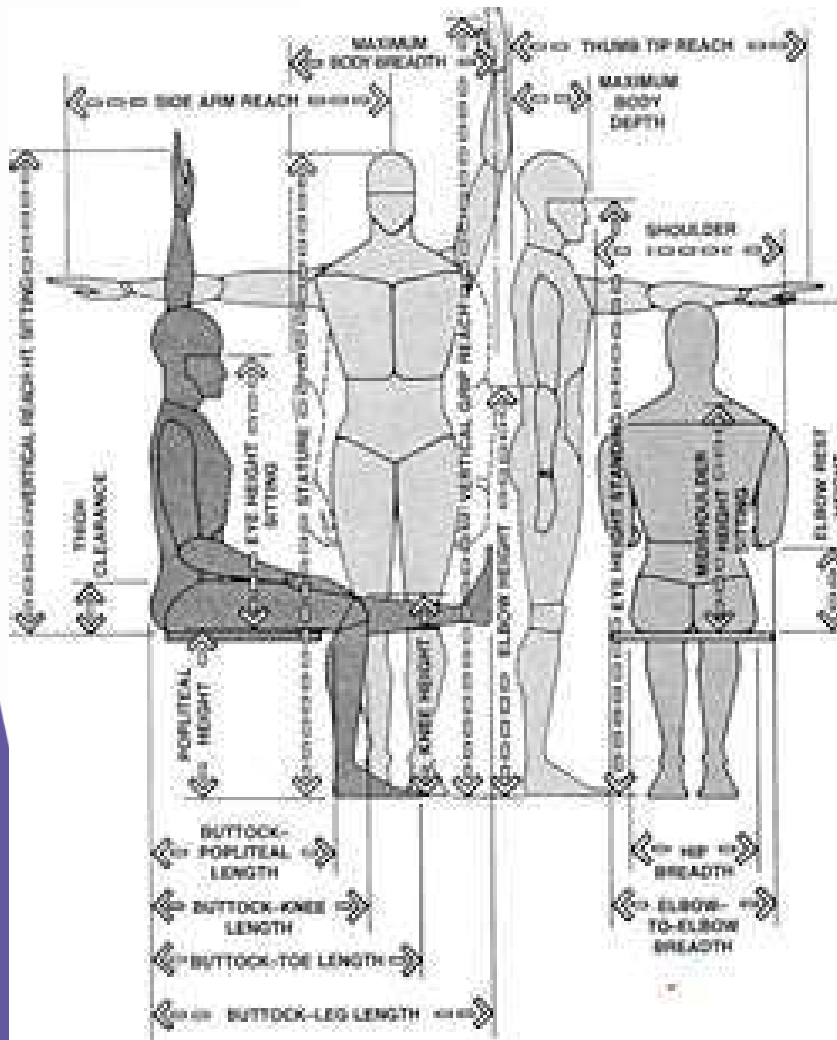
How much variation is important?



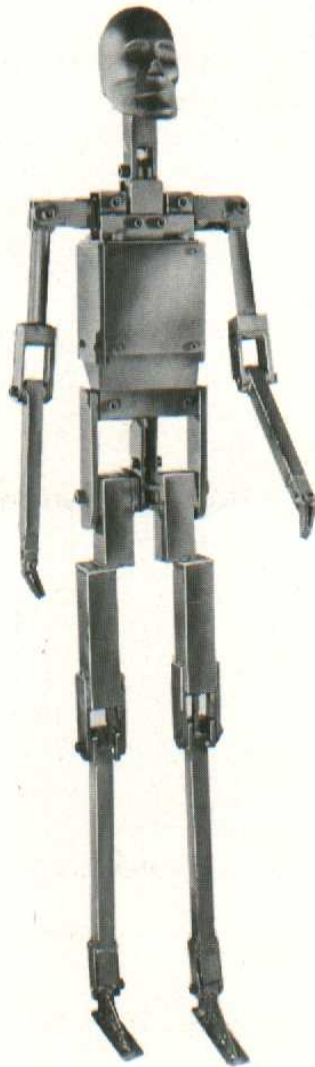
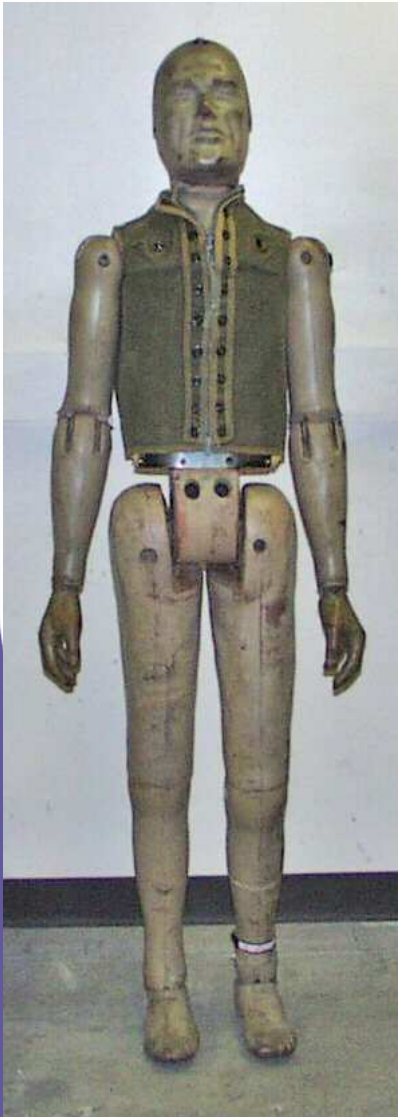
Anthropometry Variations?



Size, Shapes, Weight, ROM, etc....



Typical ATD Construction of TYPE 2 ATD's

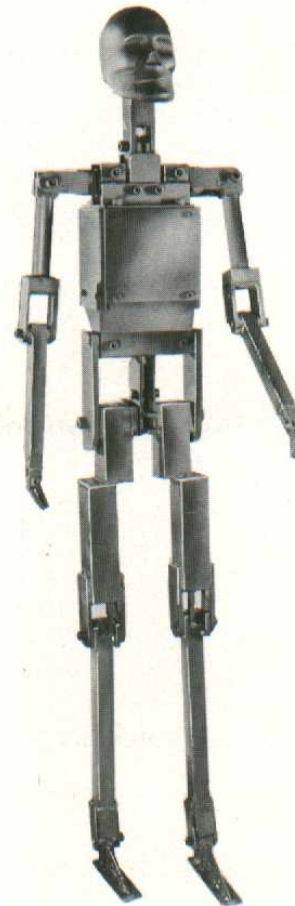


Rescue Dummies are TYPE 2 ATD's



Typical Design Features

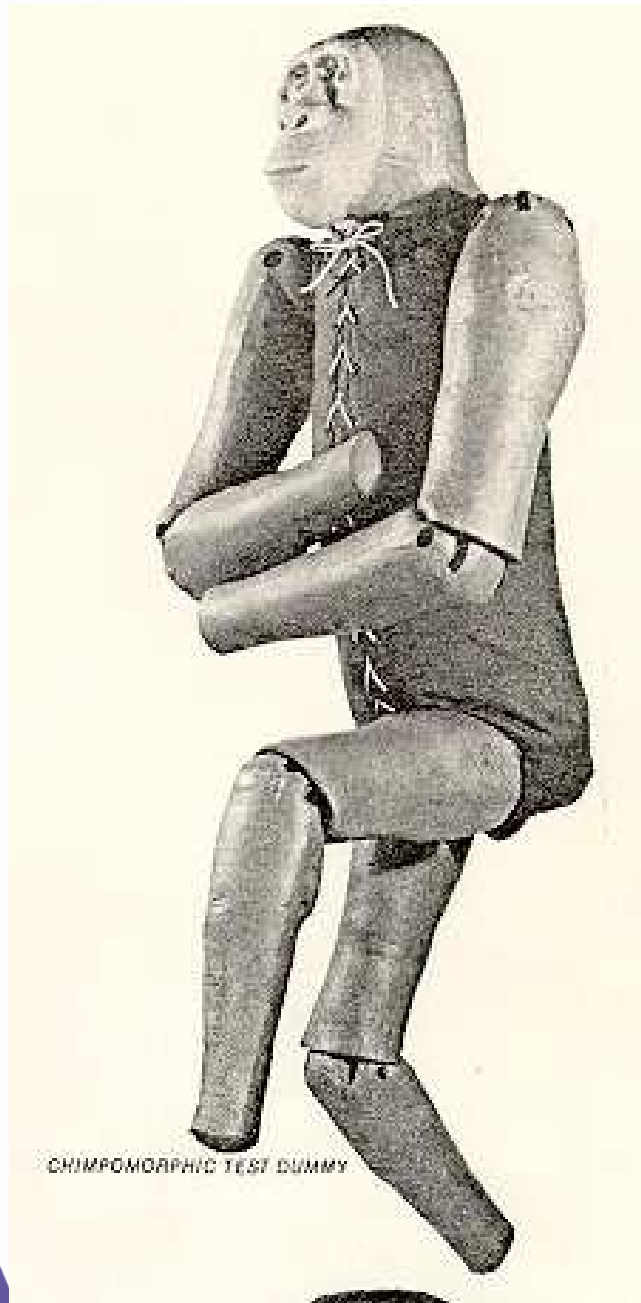
- Steel Skeleton
- Vinyl Flesh
- Joints to meet ROM
- Segment weights and CG
- Aluminum casting for skulls
- Ability to hold minimum amount of instrumentation
- Design resized for larger and smaller populations



Families of TYPE 2 Dummies



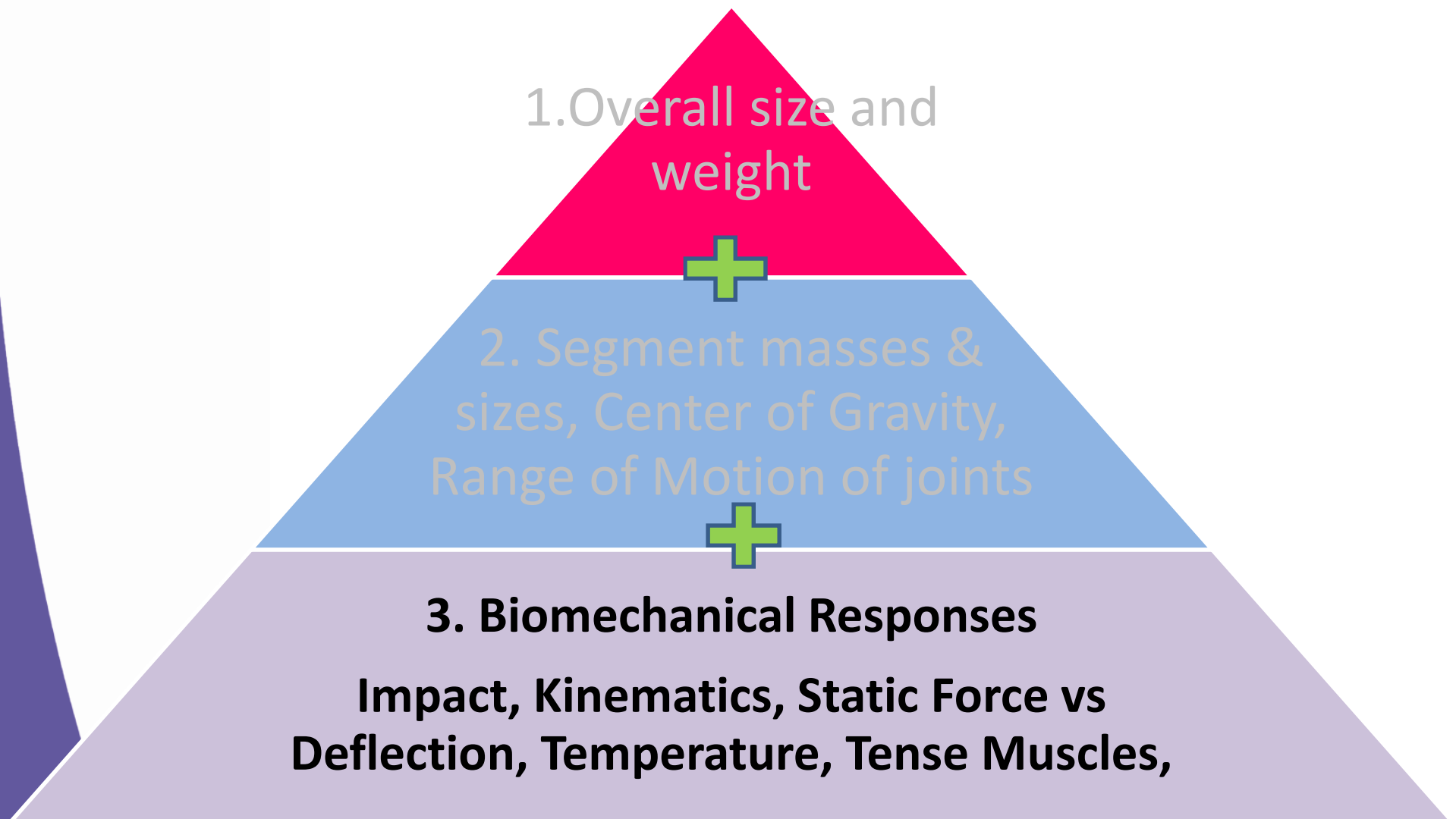
CHIMPOMORPHIC!!



CHIMPOMORPHIC TEST DUMMY

Animal Dummies
Chimps
Deer
Moose
Elk
Kangaroo

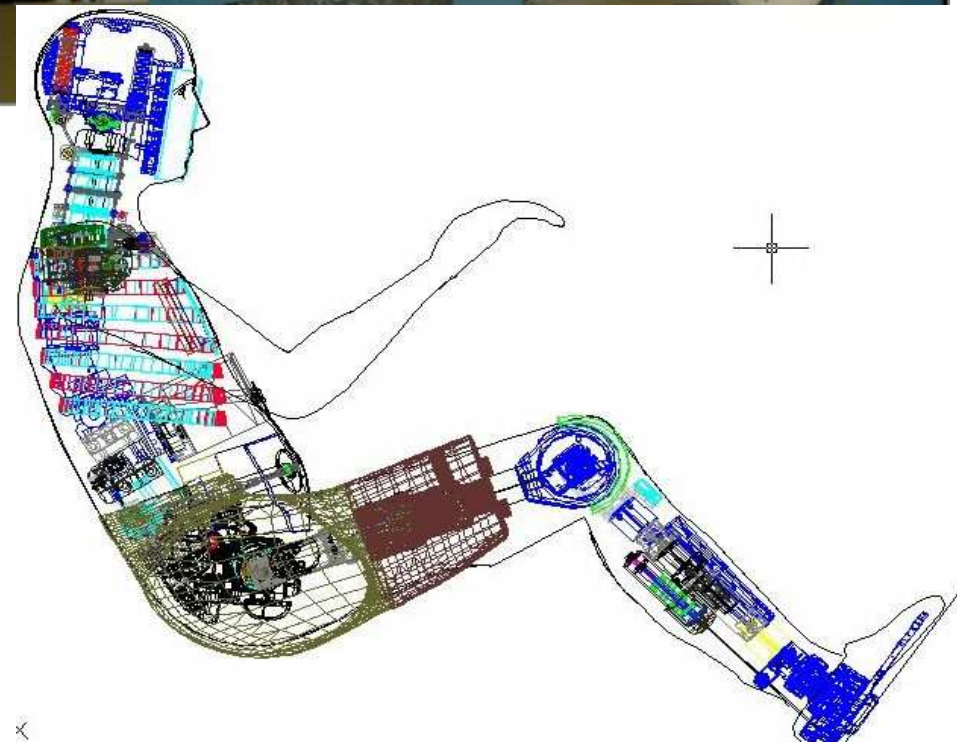
Third Type of ATD's to Represent a Human



What do we need to know to develop TYPE 3 ATD's?

- Detailed Anthropometry

- 3D Surface geometry and critical landmarks
- Skeleton 3D models
- Joint centers
- Joint range of motions
- Overall Mass, CG and MMI
- Segment mass
- Segment CG
- Segment shape
- Segment lengths
- Joint Center locations
- Relationship between skeleton and outside shape
- ROM of joints
- Measurements from different percentiles

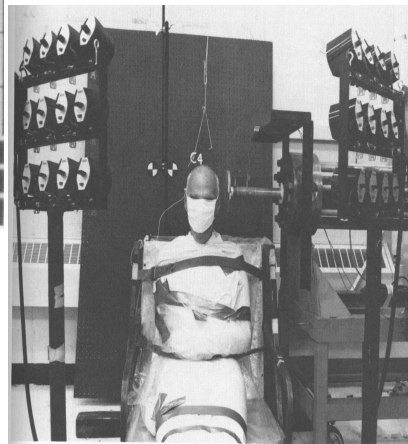
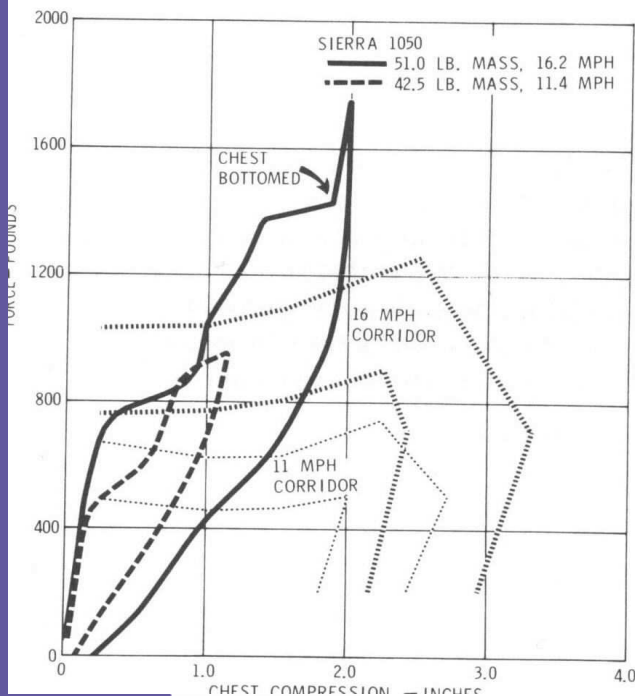
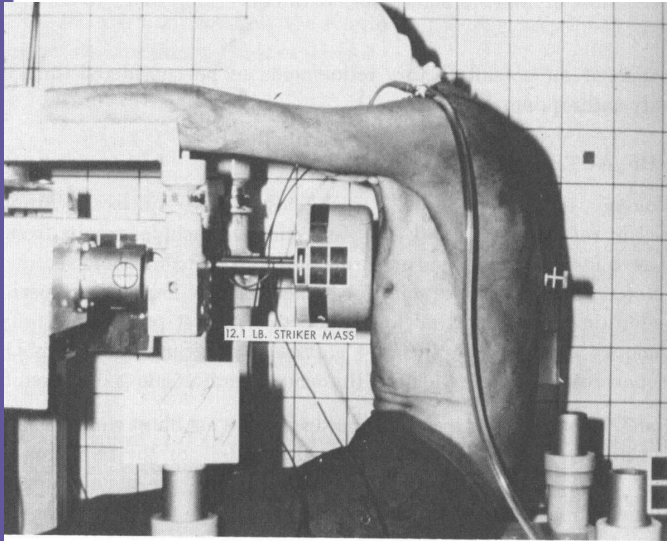


Additional Requirement Anthropometry

- Bony landmarks for the orientation of skeleton in human
 - Spine shape in various seating postures
 - Pelvis angle in various seating postures
 - Foot, ankle, and leg positions
 - Head & neck positions
 - Clavicle locations



Human Testing and Establishment of Biofidelic Corridors



- Head, Neck, Thorax, knee, abdomen, pelvis, etc.... was measured to determine dynamic response.
- Corridors for ATD performance developed

Other Methods of obtaining Human Biofidelity

Seat Belt Measurements in Race Cars

Bumper Car loading of Volunteers

NASCAR/Indy Car On Board Recorders

Football Helmet Recorders

Ear Accelerometers in Rodeo Riders

Children's Hospital of Philadelphia

Virginia Tech University

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Typical Construction of a Current TYPE 3 ATD

Biofidelic Head Impact Response



Biofidelic Neck Impact Rotation Response



CLAVICLE AND LINK



THORACIC
CHEST
BOX



SPINE
ASSEMBLY



LEG ASSEMBLY



RIBS AND
STERNUM BIB



ABDOMINAL INSERT

Biofidelic Thorax Impact Response

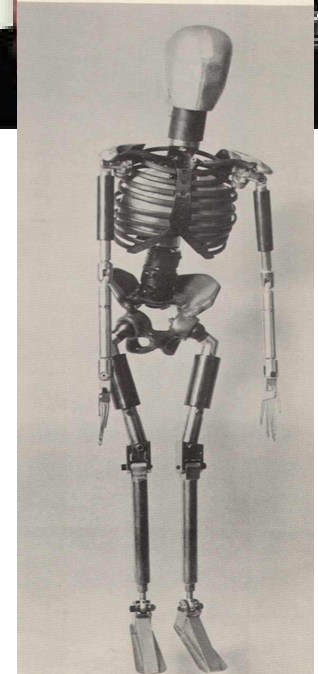
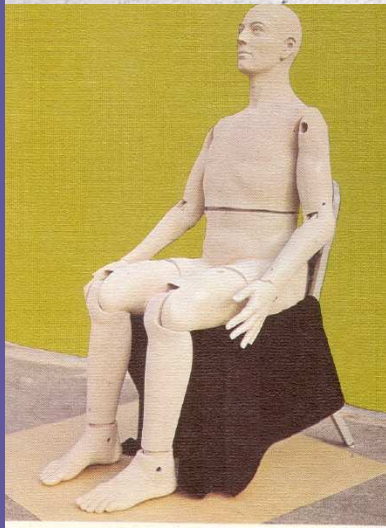
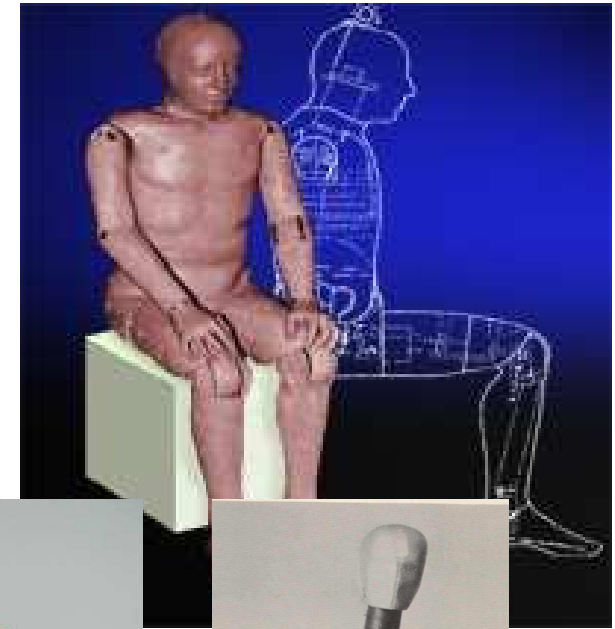


ARM
ASSEMBLY



Biofidelic Knee Impact Response

TYPE 3 ATD Family (Frontal Impact Applications)



TYPE 3 Side Impact Dummies



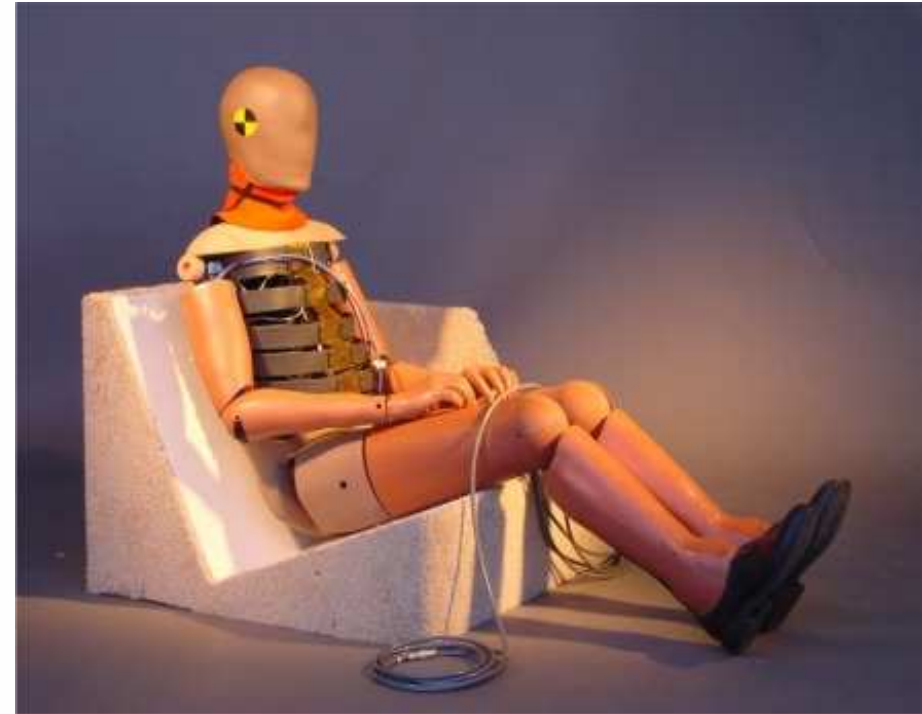
EUROSID



SID

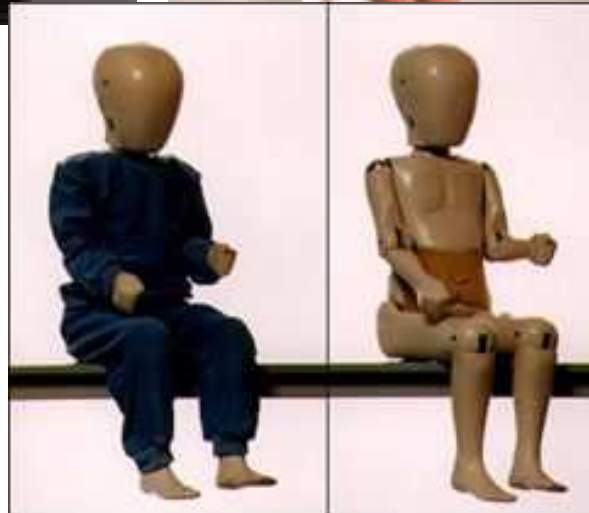
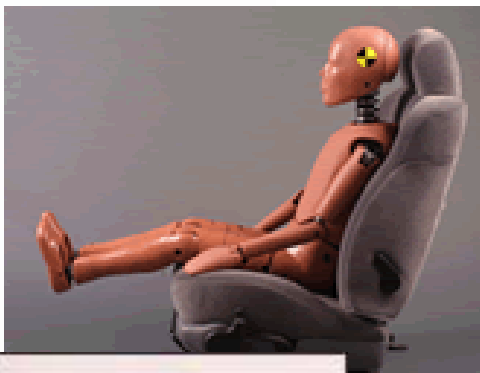
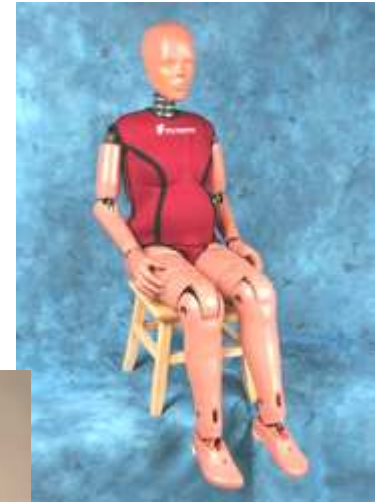


**BIOSID
& SID IIs**



**Small and Mid Sized
Worldsid**

TYPE 3 Children Dummies



Pedestrian Dummies

H-III6C



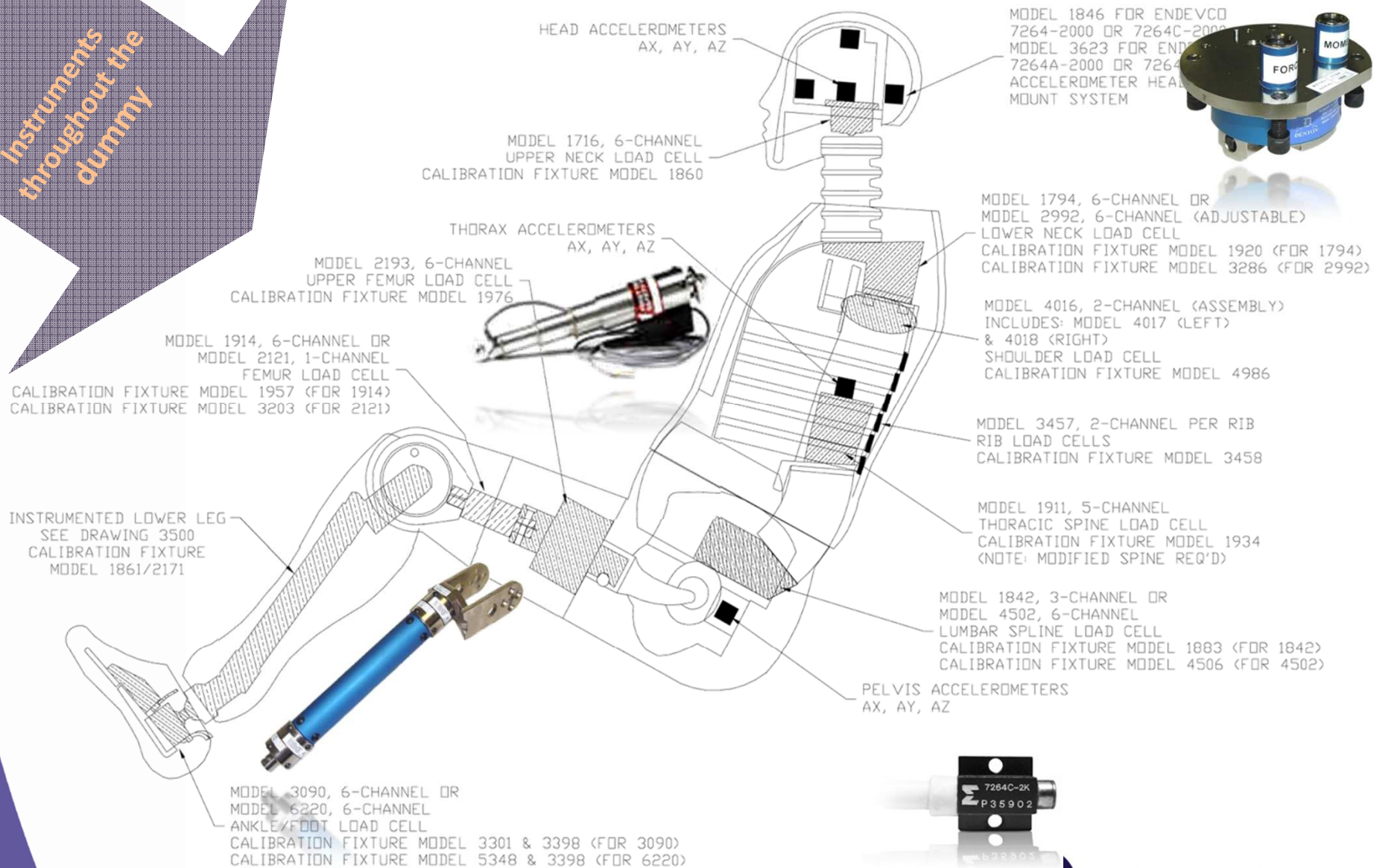
H-III50M



Polar-II



*Instruments
throughout the
dummy*



How many Different ATD's are currently made?

Frontal Impact – 14

Side Impact – 9

Rear Impact – 2

Children – 26

Aerospace/Military – 16

Pedestrian – 10

General Purpose – 1

70+ Different types plus variations on each one

30,000+ different part numbers

What are dummies made from

- Vinyl
 - 10 different compounds currently
- Rubber
 - 30 different compounds currently
- Urethanes
 - 20+ different compounds currently
- Cast Aluminum
- Steel
- Cast Bronze
- Damping material
- Foams

How do they Cost?

- Average price is 36K each
- With all the instruments over \$350K each

How Many Total Dummies Made

- Since 1946, there is estimated to be approximately 8000 dummies made.
- That is an average of about only 123 dummies a year total.

Dummy Manufacturing

- Vinyl
 - 450 + different molds
- Rubber
 - 180 + Different molds
- Urethanes
 - 200+ different molds
- Cast Aluminum & Bronze & Steel
 - 30 + patterns
- Ribs
 - Bending fixtures and heat treat racks for each rib
- Foams
 - 20+ molds for foam products





NECK

HEAD



CHEST VEST

CLAVICLE AND LINK



SHOULDER

THORACIC
CHEST
BOX



RIBS AND
STERNUM BIB

SPINE
ASSEMBLY



ABDOMINAL INSERT



LEG ASSEMBLY



STANDARD DUMMY



ARM
ASSEMBLY

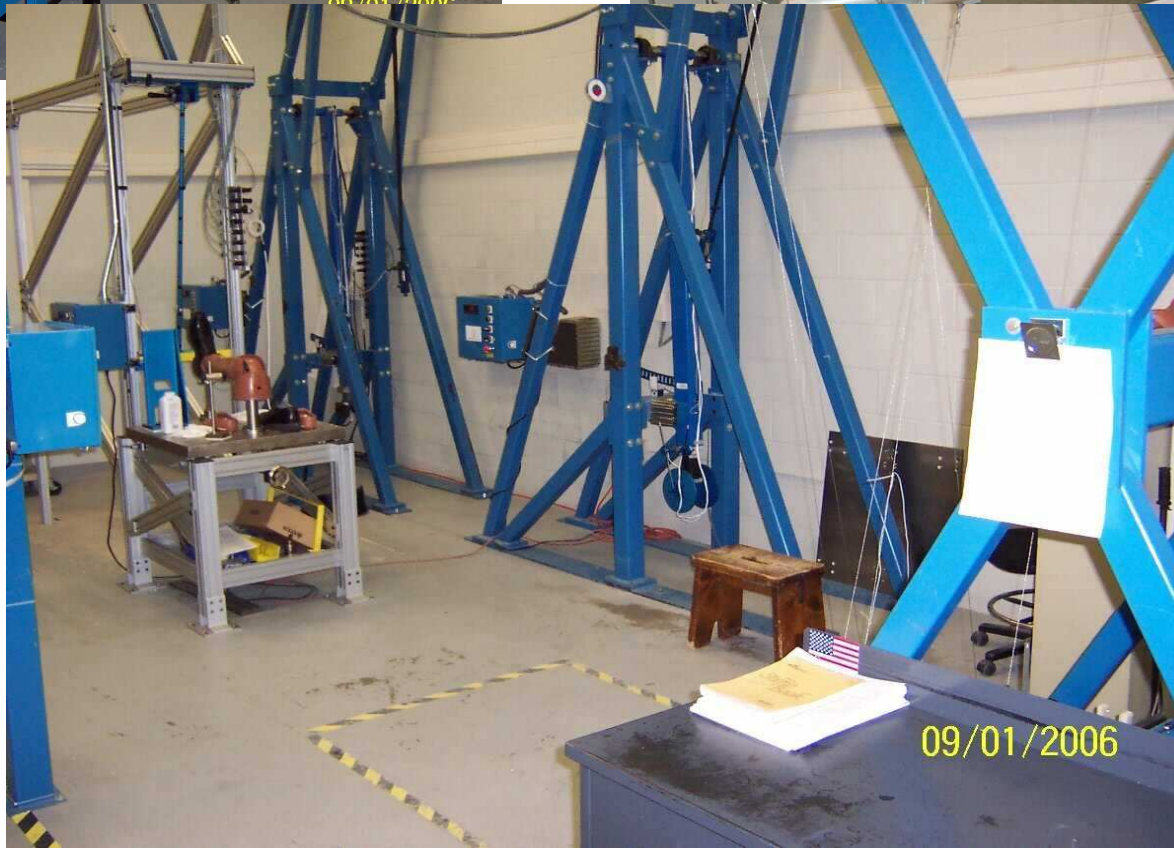
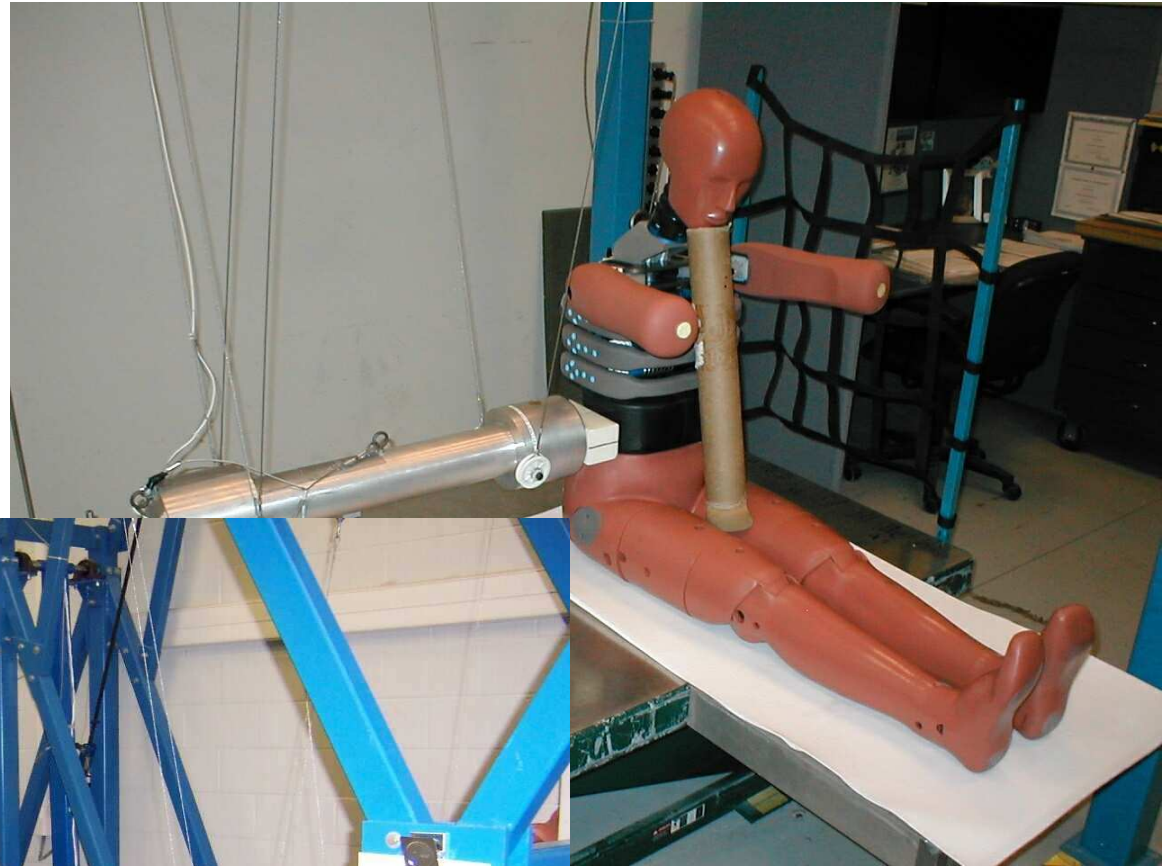
Machining

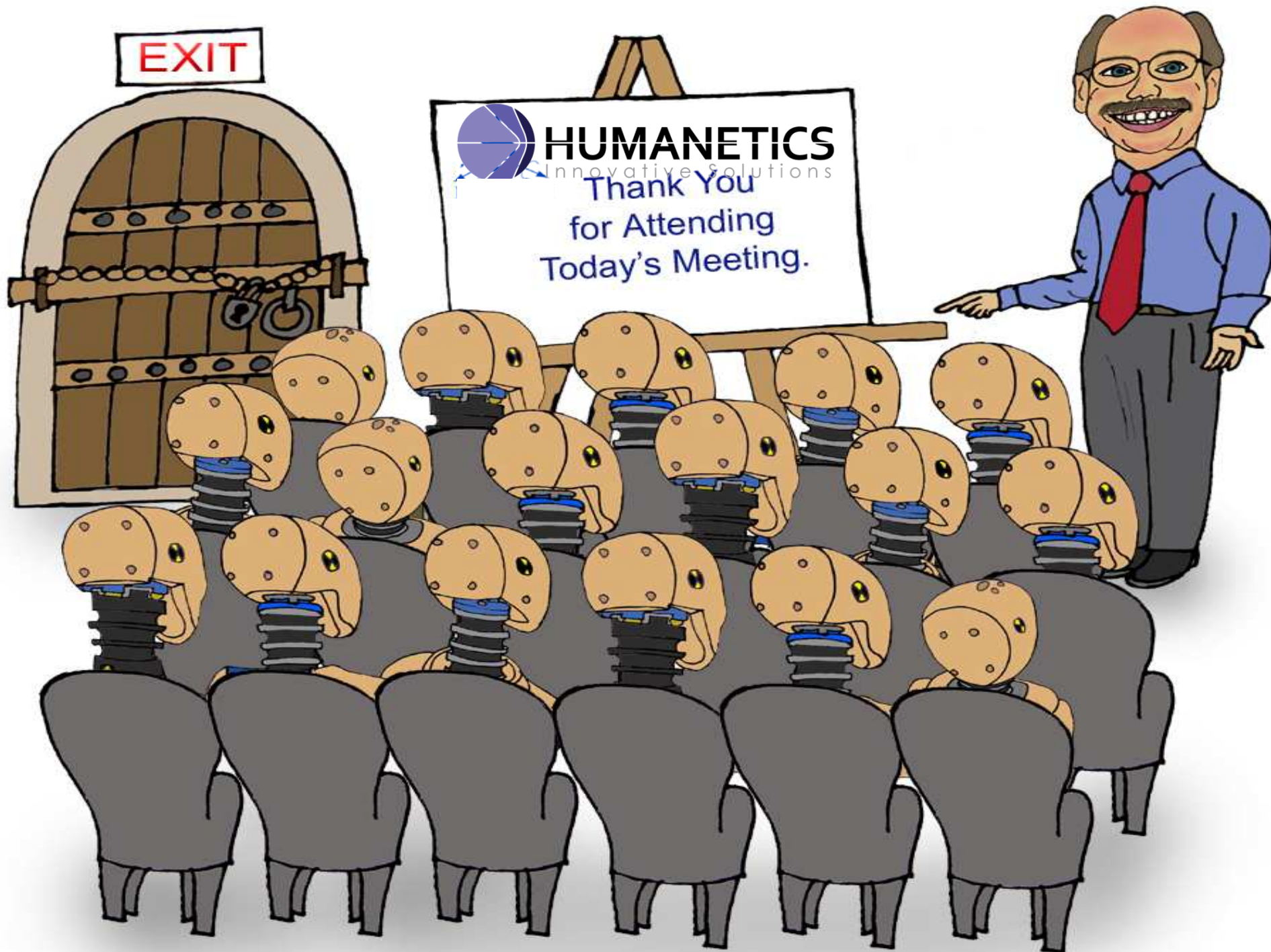


Molding, Vinyl, Rubber, Urethanes



Dummy Testing





Have A Safe Day!

